First preparatory experiments on NEET at GSI

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Nuclear excitation by electronic transition (NEET) [1] designates a mechanism of nuclear excitation induced by a transition between two bound states of the atomic system. Depending on the considered element, the surrounding environment of different atomic configurations may influence the decay rates of isomeric states.
This is supposed to be the case for ^{84}Rb in a plasma environment [2]. As shown in Fig. 1, it is possible to excite a nucleus from an isomeric state to a higher state with different half-life. In ^{84}Rb this transition is around 3.5 keV. The ^{84}Rb isomeric state could be efficiently produced by the Unilac with a 76Ge(11B, 3n)84Rb reaction, alternatively with a 76Ge(12C, p3n)84Rb reaction. For an efficient NEET rate, high charge states (30-34+) are needed to have an efficient energy matching. Depending on different plasma models, especially for higher Z-elements the ionic structure depending on the temperature becomes hard to predict - LTE calculations suggest 300-400 eV, while non-LTE calculations suggest 2-3 keV to reach the desired ionization degrees.

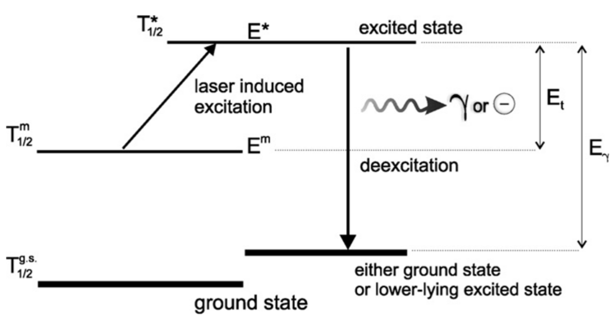

Figure 1: Principle of the NEET process

To determine whether the PHELIX parameters available at Z6 in the long pulse option are sufficient to reach these high charge states, we did a first test run to record the spectra of a RbF target. Two spectrometers recorded time integrated spectra of the target and they were used in different configurations to observe different energy ranges. One was based on a HoPG crystal for high reflectivity, the other one was a Mica crystal for high spectral resolution.
The Phelix laser was used at an energy of 150 J(2ω) at a pulse length of 1.4 ns with a focus diameter of d=100μm. This corresponds to an intensity of 10^{15}W/cm^2 on target. Additionally, we tried to increase the laser energy by using a pulse train of Phelix, each laser pulse at an energy of 150 J, but separated by 3-4 ns to fulfill the damage threshold criterions.

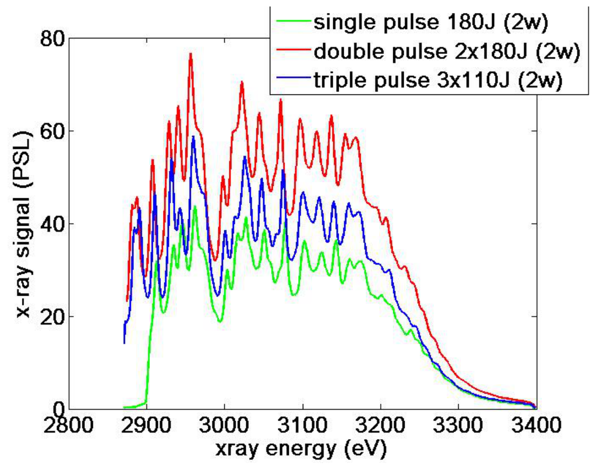

Figure 2: Different spectra recorded with a HoPG crystal

Some of the spectra recorded with the HoPG spectrometer are shown in Fig. 2. They do not show dramatic differences when the energy is increased, however the overall amount of x-rays is increased.

The analysis of the spectra in detail is still ongoing. The difficulty is that there are no experimental data and only limited theoretical calculations available for Rb plasmas to compare them to. The results of a first analysis indicate that we observed charge-states in the range of 25-27+, which would be a bit too low for our experiment. However we intend to continue our efforts into this direction. The laser focus will be further optimized by using a deformable mirror at the Phelix laser and we intend to exploit the advantages of undercritical foam targets which are highly doped with high-Z elements to reach higher temperatures. In addition, we want to specifically analyze the corona of the target to see, whether the undercritical part reaches a sufficiently high temperature and charge states to perform a final experiment at GSI to observe and measure the NEET rate of ^{84}Rb in a plasma.

References

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